A Sustainable method for turning fungi cultivation waste into green chemicals: Enhanced volatile fatty acid production from already fermented potato protein liquor

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Introduction

The potato can be grown under a wide range of conditions, making it a common crop worldwide, including in all EU countries. The global annual production of potatoes is now over 370 million tons, of which 826 400 tons of it produced in Sweden in 2021, corresponding to an area under cultivation of 23 750 ha. The yield per hectare for starch potato processing in Sweden is estimated at 41 950 kilos (Jordbruksverket, 2022). The potato industry entails side streams that take up a significant part of the original biomass. Especially in southern Sweden, potato starch production generates a large amount of low-value residuals consisting of potato liquor and potato pulp (Kuktaite et al., 2015). The potato liquor is treated with steam to coagulate the protein fraction, which is separated using a decanter. The remaining potato liquid, which mainly consists of the soluble fraction of the waste from potato starch production, is concentrated to form potato protein liquor (PPL). Then, the potato fibers are also filtered out using belt press filters by dewatering the pulp and fibres from the potatoes. Together with processing costs and stricter EU requirements, the potato and starch industry is forced to use valuable resources responsibly and develop a more efficient approach that can produce more value-added products from the by-products (Ahokas et al., 2014). Therefore, efficient utilization of protein-rich side streams is important for the starch industry.

One of the further available valorization method can be anaerobic digestion as the effluent from fungal cultivation that contains residuals, unconverted organics and fungal metabolites that can be used to maximize value creation/extraction from potato starch industry by acidogenic fermentation and the production of volatile fatty acids (VFAs). Increasing resource efficiency by maximizing the utilization of nutrients in a used resource is a step further than converting organic waste into bio-based resources and also is a major contribution to sustainable production with higher circularity/recyclability. In this study, the potential for high-yield VFA production from the fungi cultivation waste stream, which is FPPL, was investigated. The pH control without chemical addition (adjustment of I:S ratio) and methanogen inhibition in the initial batch fermentation and the influence/choice of inoculum during membrane-based VFA recovery on VFA composition and production were evaluated. Changes in VFA, MBR performance, and inoculum activities were analyzed to determine the underlying mechanism for the efficiency of VFA production by anaerobic digestion of FPPL. For this purpose, robust semi-continuous identical immersed MBRs (iMBRs) operated at uncontrolled pH with chicken manure (CKM); MBR-1, and cow manure (CM); MBR-2, were studied.

Material and methods

In this study, fermented potato protein liquor (FPPL), a waste stream from fungi cultivation of by-product of the potato starch industry, was used as substrate. Cow manure (CM) and chicken manure (CKM) inoculums were provided from Hushållningssällskapet Sjuhärad (Länghem, Sweden) and from an egg-laying farm Sjömarkens Hönsgård AB (Borås, Sweden), respectively.

Thermal shock pretreatment (80°C-15 min) by using water bath applied CKM, CM and FPPL were used in the anaerobic batch experiments. The assays were carried out under mesophilic conditions (37 ± 1°C) for 23 days, using 120 mL glass serum bottles as reactors. Batch acidogenic fermentation experiments were performed in triplicate with a working volume of 80 mL and inoculum to substrate ratios of 1:1 and 1:4 (at VS basis) in parallel (Table 1.). Two identical iMBRs that includes second generation Integrated Permeate Channel (IPC) membrane panel inserted into the reactor were used (Figure 1) and operated semi-continuously at 37 °C. The anaerobic iMBRs have a working volume of 3.5 liters. The IPC flat- sheet membranes were developed by Doyen et al. (2010) and supplied by the Flemish Institute of Technological Research (VITO NV, Mol, Belgium). The flat sheet membrane was made of hydrophilic polyethersulfone (PES) coated on both sides with a spacer fabric.

Table 1. Experimental setup of batch assays

FPPL with CKM as inoculum					
Conditions	Substrate and inoculum	Organic loading rate (OLR) (g VS/L)	Initial pH	Set pH	
				pH=7.90	pH=7.56
1	CKM	0.5	8.68	◆	
2	CKM	0.2	8.68		◆
3	CKM and FPPL	0.5:0.5	7.90	as it is pH	
4	CKM and FPPL	0.2:0.8	7.56	as it is pH	

FPPL with CM as inoculum

Conditions	Substrate and inoculum	Organic loading rate (OLR) (g VS/L)	Initial pH	Set pH pH=7.41	pH=7.02
5	CM	0.5	7.79	◆	
6	CM	0.2	7.79		◆
7	CM and FPPL	0.5:0.5	7.41	as it is pH	
8	CM and FPPL	0.2:0.8	7.02	as it is pH	

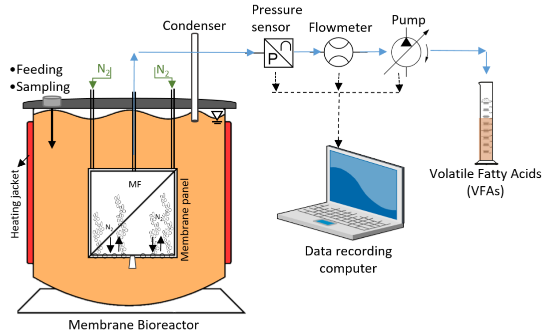

Figure 1. Schematic diagram of membrane bioreactor setup

Results and discussion

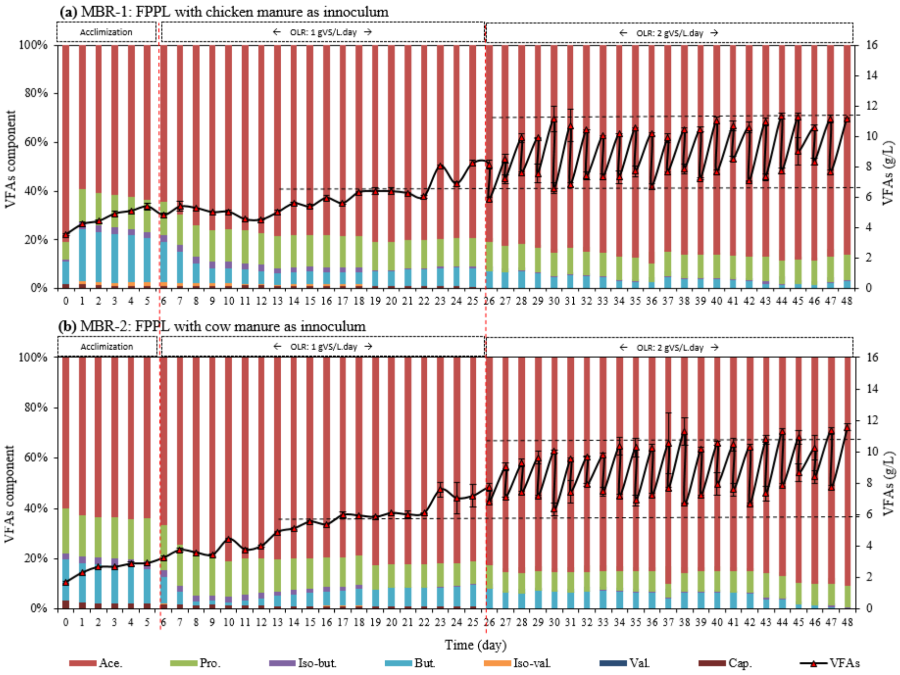

Figure 2. Concentration and distribution of VFAs during fermentation in the (a) MBR-1 and (b) MBR-2 at OLR 1 and 2 gVS/L.d

The increase in organic loading rate (OLR) can be used to boost VFAs production (11-12 g/L VFAs at an OLR of 2 g VS/L.d) (Figure 2).

Conclusions

Based on the data obtained in this study, researchers can be motivated to develop a biorefinery that can reuse waste FPPL to produce sustainable profitable products in order to create the highest value from nutrients.

References

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